DRAFT
PROBLEM FORMULATION
FOR ECOLGOCIAL RISK ASSESSMENT AT
OPERABLE UNIT 3
LIBBY ASBESTOS SUPERFUND SITE

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1.0 INTRODUCTION

Problem formulation is a systematic planning step that identifies the major concerns and issues to be considered in the ERA, and describes the basic approach that will be used to characterize the potential risks that may exist (USEPA, 1997). Problem formulation usually begins with the development of a conceptual site model that identifies sources of chemical release to the environment, evaluates the fate and transport of chemicals in the environment, and identifies exposure pathways of potential concern for ecological receptors. Based on the conceptual site model, assessment endpoints, measurement endpoints, and testable hypotheses are identified that form the basis of the ecological risk assessment (ERA).

As discussed in USEPA guidance (USEPA, 1997), problem formulation is an iterative process, undergoing refinement as new information and findings become available (Figure 1-1). Problem Formulation can be completed as part of a Screening Level Ecological Risk Assessment (USEPA, 1997) but is primarily a ~~primary~~ component of the baseline ecological risk assessment.

This document represents the initial Problem Formulation for the ecological risk assessment for asbestos at the Libby Operable Unit 3 (OU3) site in Libby, Montana. OU3 includes the former vermiculite mine and the geographic area (including water bodies ~~ponds~~) surrounding the former vermiculite mine that has been impacted by releases from the mine. Non-asbestos contaminants at Libby OU3 will be initially evaluated ~~addressed~~ in a Screening Level ERA. A Screening Level ERA will ~~could~~ not be completed for asbestos as toxicity screening benchmarks were not ~~readily~~ available for any environmental media for ecological receptors (soil, sediment, air, water and/or biota).

This Problem Formulation is limited to asbestos as a preliminary contaminant of concern and represents the initial planning for the Baseline Ecological Risk Assessment (BERA). The Problem Formulation (planning step of the risk assessment) precedes the study design and Data Quality Objectives (DQOs) process that will be used to define the type, quality, quantity, purpose, and intended uses of data to be collected (USEPA, 2006) at Libby OU3 to support the BERA. It is anticipated that a Phase II Sampling and Analyses Plan (SAP) for Libby OU 3 will be completed in early ~~2007~~ 2008.

2.0 BACKGROUND AND PROBLEM DEFINITION

This fig should be fixed (per Nov meeting)

2.1 Site Description

Libby is a community in northwestern Montana that is located near a large open-pit vermiculite mine. The mine location and preliminary study area boundary of Operable Unit (OU) 3 that was established as part of the Phase I Sampling and Analyses Plan (SAP) (USEPA, 2007) are shown in Figure 2-1. EPA established the preliminary study area boundary for the purpose of planning ~~and developing~~ the initial scope of the RI/FS for OU3. The preliminary study area boundary includes the former vermiculite mine and the surrounding geographic area that may have been impacted by current and/or historical releases and subsequent migration of hazardous substances and/or pollutants or contaminants from the mine. This preliminary boundary may be revised based on the results of the Phase I sampling. The revised boundary will be based on the extent of environmental contamination associated with releases that may have occurred from the mine site.

The terrain in OU3 is mainly mountainous with dense forests and steep slopes. The major mountain ranges in the area are the Cabinets to the southwest and the Parcells to the northeast. Land ownership in OU3 is shown in Figure 2-2. Kootenai Development Corporation (KDC), a subsidiary of W.R Grace & Co., owns the mine area and the immediately adjacent portion of the off-mine area. The majority of the surrounding land is owned by the United States government and is managed by the Forest Service, with some land parcels owned by the State of Montana and some owned by Plum Creek Timberlands LP for commercial logging. There are numerous smaller parcels adjacent to the Kootenai River. All land parcels within the study area boundaries that are currently residential are excluded from OU3. These current residential properties are included as part of OU4, and as such, investigation and cleanup of these properties is within the scope of OU4.

Climate

Northern Montana has a continental climate characterized by relatively hot summers, cold winters, and low precipitation. Table 2-1 presents climate data collected at the Libby NE Ranger Station, which is located just west of the town of Libby near the Kootenai River. Average summer high temperatures (^{o}F) are in the upper 80s, and low temperatures are in the 40s, while winter highs are in the 30s and lows are in the teens. The western mountain ranges cause Pacific storms to drop much of their moisture before they reach the area, resulting in relatively low precipitation, averaging about 18 inches per year. The most abundant rainfall occurs in late spring/early summer. In the winter months, snowfall averages 54 inches each year and snow cover typically remains on the ground from November through March.

update

Remedium Group, Inc., a subsidiary of W.R Grace & Company, install~~ed a~~ meteorological station at the mine in December 2006. Data collected at ~~this station~~ through August 2007 indicate that winds are predominantly to the northeast (Figure 2-3). Local wind patterns and climate conditions may be significantly affected by local ~~topography~~ and ~~ground~~ elevation. Data collection is continuing to assess variability during the summer and fall seasons.

We're past Summer & Fall seasons

Hydrologic Setting

The mine area is contained completely within the Rainy Creek watershed, which includes Carney Creek and Fleetwood Creek (Figure 2-4). Rainy Creek originates between Blue Mountain and the north fork of Jackson Creek at an elevation of about 5,000 feet, and falls to an elevation of 2,080 feet at the confluence with the Kootenai River approximately 2.5 miles downstream of the

Libby Dam and 5.5 miles upstream of the town of Libby (Zinner, 1982). The area drained is approximately 17.8 square miles, including 3.8 and 2.2 square miles associated with Fleetwood Creek and Carney Creek, respectively.

Small springs are reported in the area of the mine (Zinner, 1982) associated with Fleetwood and Carney Creeks. Monitoring performed in the early 1990s observed Carney Creek flows originating from beneath a waste rock pile. Fleetwood Creek flows through a portion of the disturbed area before flowing into the tailings impoundment, which was constructed within the former Rainy Creek channel. Water entering the tailings impoundment (from Rainy and Fleetwood creeks) infiltrates into the tailings and exits via the toe drain at the base of the dam. This flows into a lower pond in the Rainy Creek channel that was constructed to provide a water supply for mining operations. Discharge from this pond mixes with inflow from Carney Creek and flows down Rainy Creek to the Kootenai River, with some seasonal gain in flow, most likely due to groundwater input.

Flows in the Kootenai River are controlled by the Libby Dam, which was constructed in the late-1960s and early-1970s as part of the Columbia River development for flood control, power generation, and recreation. The drainage area above the dam is approximately 9,000 square miles. Daily water outflow plans[1] for October 2006 through August 2007 show lowest discharge flows in March and October at approximately 4,000 cubic feet per second (cfs) and maximum discharge flows in late May/early June at 26,600 cfs.

Table 2-2 presents designated uses for Rainy Creek and the Kootenai River near and downstream of the mine area as classified by the State of Montana Administrative Rules Chapter 30 Water Quality Subchapter 5 (§17.30.609 for the Kootenai River drainage). The State of Montana has established numeric standards for the protection of aquatic life and human health associated with the designated uses. The numeric standards are set forth in the Montana Department of Environmental Quality Circular DEQ-7 – Montana Numeric Water Quality Standards.

Hydrogeologic Setting

An investigation of groundwater at the mine performed in the early 1980s (Zinner, 1982) included more than 100 shallow boreholes (less than 200 feet) and two deep holes (900-1,000 feet). The general hydrogeological setting appears to be recharge in the mountains above the mine with some expression of groundwater at the surface as springs near the mine area and recharge to lower Rainy Creek. Regional groundwater flows have not been assessed at this time.

Zinner (1982) identified two types of aquifers in this geologic setting; a layer of altered vermiculite pyroxenite (upper 100 to 200 feet) and the unaltered biotite pyroxenite surrounding the alteration zone. Except where mining has removed the surface material, an overburden layer

[1] Available from http://www.nwd-wc.usace.army.mil/ftppub/project_data/yearly/lib_wy_qr.txt

consisting of reworked glacial deposits blankets most of the area. The overburden is less permeable than the vermiculite pyroxenite and acts as a semi-confining layer, holding groundwater under artesian conditions. Holes drilled in the altered zone produced up to 50 gallons per minute water. This zone appears to be capable of storing and producing considerable quantities of water.

Geologic Setting

The mine is located in a region of the Precambrian Belt Series of northwestern Montana that has been intruded by an alkaline-ultramafic body. The Rainy Creek Igneous Complex comprises the upper portion of this intrusion. Hydrothermal alteration of the biotite pyroxenite intrusion produced the large, high-quality vermiculite deposit. The vermiculite content of the ore varies considerably within the deposit, ranging from 30 to 84%.

Occurrence and Nature of Asbestos at the Mine

Fibrous and asbestiform amphiboles are present in association with the vermiculite ore. A significant portion of the fibrous amphiboles are located along cross-cutting veins and dikes and in the altered pyroxenite wall rock adjacent to them. The alteration zones, dikes, and veins that range in width from a few millimeters to meters in thickness are found throughout the deposit. Amphibole content in the alteration zones of the deposit is estimated to range between 50 to 75%. Additional alteration minerals include calcite, K-feldspar, vermiculite, talc, titanite, limonite, pyrite, quartz, and albanite.

The U.S. Geological Survey (USGS) performed electron probe micro-analysis and X-ray diffraction analysis of 30 samples obtained from the exposed asbestos veins to identify compositional changes across the veins (Meeker et al. 2003). Results indicate that a variety of amphiboles exist at this site, including winchite, richterite, tremolite, actinolite, and magnesioriebeckite. The EPA refers to this mixture of amphibole minerals as Libby Amphibole (LA).

Mine Operations and Current Features

Figure 2-5 shows the current mine features and location of historical operations. The mine was operated from 1923 until 1990 and was open pit except for a short period in the early period of operations. The mine area is heavily disturbed by past mining activity and is largely devoid of vegetation. There are a number of areas where mine wastes have been disposed (Figure 2-5), including waste rock dumps (mainly on the south side of the mine), coarse tailings (mainly to the north of the mine), and fine tailings (placed in the tailings impoundment on the west side of the site).

The basics of ore processing did not change over the period of operation, although unit operations were changed as ore quality decreased and technology improved, and in response to concerns over dust generation (Zucker, 2006). In general, rock was removed to allow access to the vermiculite or separated from the vermiculite in the mine pits and dumped over the edge to form waste rock piles (see Figure 2-5). After 1971, ore was processed to separate out vermiculite product by crushing, screening or water floatation, with those operations generally occurring in the mill area (Figure 2-5).

Mining increased dramatically in scale over the first 25 years of mining, with just 100 tons of vermiculite product shipped per year in the 1920s, rising to over 200,000 tons by 1950 (Quivik, 2002). Thereafter, production rates were generally in the range of 150,000 to 250,000 tons per year.

A storage and loading facility along the river at the mouth of Rainy Creek was built in 1949. It included a 600-foot conveyor belt for carrying material across the Kootenai River, and a loading facility along the Great Northern Railroad tracks on the south side of the river.

A new concentrating plant began operations in 1954 in the general milling area (Figure 2-5). This plant was designed to separate the vermiculite from ore that contained less than 35% vermiculite. Continued refinements led to implementation of a wet process, in which a froth flotation process was coupled with shaking tables to separate waste rock from the vermiculite. The dry mill continued to operate. By 1960, the concentration of ore took place along one of two processes (Quivik, 2002). After passing through a two-inch grizzly, ore went to one of five storage bins at the mill. Ore was blended and sent to the primary screens at the mill where water was added. Oversize material was concentrated in jigs and dried in rotary driers. The material was then crushed using hammer mills, and roll crushers before being screened, with finer material further separated using spiral concentrators, dewatered and dried before being screened for product. The process generated two types of waste material; coarse tailings which were disposed in a pile to the north (Figure 2-5) and fine tailings which appear to have been discharged to Rainy Creek until a tailings impoundment was constructed in 1971.

W.R. Grace & Co.-Conn. (then known as W.R. Grace & Co.) took over mining in 1963. In 1971, they undertook a major expansion to increase capacity and improve the beneficiation process. It was at this time that the tailings impoundment was built to provide for settlement of the fine tailings produced by the new process and to recover water for reuse (Schafer, 1992). The dam was designed and constructed in stages, with a 50 foot high starter dam constructed in 1971, immediately downstream of an older, existing dam. Additional construction phases in 1975, 1977, and 1980 raised the top of the dam to a total height of 135 feet measured from the downstream toe.

Remedium reviewed historic information on mining operations at the site and reported that in a typical year about 5 million tons of rock was mined to generate 220,000 tons of vermiculite product. Primary waste materials were waste rock (3.5 million tons per year) and tailings (1.1 million tons per year), with lesser amounts of oversize rock and screening plant concentrate wastes. As higher quality ores were depleted and lesser quality ores were mined, various reagents were used to facilitate the separation. Reported reagents include #2 Diesel Fuel (typically between 1.2 and 5.4 million pounds per year), Armeen T (Tallow Alkyl Amine; 100,000 to 500,000 pounds per year), fluorosilicic acid (50,000 to 240,000 pounds per year) and lesser quantities of flocculants, defoamers, frothers and other reagents.

2.2 Problem Definition

Historic mining, milling, and processing of vermiculite at the site are known to have caused releases of vermiculite and LA to the environment. Inhalation of LA associated with the vermiculite is known to have caused a range of adverse health effects in exposed individuals, including workers at the mine and processing facilities (Amandus and Wheeler 1987, McDonald et al. 1986, McDonald et al. 2004), as well as residents of Libby (Peipens et al. 2003).

Starting in 2000, EPA began taking a range of cleanup actions at the site to eliminate sources of LA exposure to residents and workers using CERCLA (or Superfund) authority. In the early stages, efforts were focused mainly on wastes remaining at former vermiculite processing areas (the screening plant, export plant, etc.). As work progressed, attention soon shifted to cleanup of current homes and workplaces in the main residential/commercial areas of Libby, designated by EPA as OU4 of the Libby Asbestos Site. EPA listed the Libby Asbestos Site on the National Priorities List in October 2002.

To date, Superfund investigation and cleanup activities have been conducted by EPA within OU4 and some of the historic processing areas in and around the town of Libby. An investigation of the nearby town of Troy, designated as OU7, began in the summer of 2007. Relatively little information has been collected to evaluate contaminant levels and releases associated with the mine site itself (OU3). However, this area is of potential concern to EPA since the area is used by humans for a variety of recreational activities as well as for logging, and is also habitat to a wide variety of ecological receptors. Contaminants of potential concern in OU3 include not only LA, but any other mining-related contaminants that may have been released to the environment. Therefore, the problem to be addressed is the collection of sufficient information to allow reliable evaluation of risks to humans and ecological receptors from exposure to mining-related releases in OU3 and to support the development and evaluation of remedial alternatives to address unacceptable risks. This will occur over multiple, phased sampling events. The first sampling event (Phase I, as described in this document) is not expected to provide data that will be sufficient to fully characterize the nature and extent of contamination or to support a risk assessment.

3.0 SUMMARY OF EXISTING SITE DATA FOR ASBESTOS

Prior to the Phase 1 sampling effort (USEPA, 2007), only limited data exist on the nature of source materials at the mine site and on the identity and levels of mining-, processing-, and mine waste disposal- related releases from the mine to surrounding areas in OU3. The following sections provide a summary of the OU3-specific data that were identified prior to the Phase 1 sampling effort and those collected during Phase 1. The review of data is limited only to asbestos.

3.1 Soils and Mine Wastes

Prior to Phase 1

As part of site characterization associated with EPA's initial response activities at the Libby Asbestos Site, EPA collected numerous soil samples along roadways within OU3 (EPA 2000a, 2005; CDM 2002, 2003). Figure 3-1 presents the locations of soil samples collected along Rainy Creek road, Highway 37 N, and a forest service road within OU3. In addition to the roadway samples, EPA also collected surface soil samples from two logging areas within OU3 (EPA 2000a). Table 3-1 summarizes the asbestos levels measured in these soil samples. Asbestos levels in roadway soils ranged from non-detect up to 7-8% while most samples from logging areas contained asbestos levels less than 1%.

Phase 1 Sampling Results

[will insert when data becomes available…..]
Figure 3-2 Location of Soil and Mine Waste Samples
Table 3-2 Results for Asbestos Analyses in Soils and Mine Wastes

3.2 Surface Water and Sediments

Prior to Phase 1

Prior to 2001-2002, sampling of surface water and sediments were limited. Figures 3-3 and 3-4 show the locations of available surface water and sediment samples, respectively. Zinner (1982), Shafer and Associates (1992-1995), and W.R. Grace (2006) provide historic information on surface water quality from 1981 through 1994. Water was typically pH neutral with total dissolved solids content less than 500 mg/L and low sulfate concentrations; acid mine drainage is not indicated. Asbestos concentrations in water from Lower Rainy Creek (below the confluence of Carney Creek and Rainy Creek), Carney Creek and in the tailings pond were measured above the drinking water Maximum Contaminant Level (MCL). Concentrations were highest in Lower

Rainy Creek. This may be the result of old mining practices in which tailings were discharged directly into the Rainy Creek drainage rather than into an impoundment (Shafer, 1993).

More recently (2001-2003), EPA collected several surface water and sediment samples from Rainy Creek and the tailings pond (EPA 2000a, CDM 2003). Table 3-3 and 3-4 provide the surface water and sediment results, respectively. Asbestos was detected in all surface water samples collected from Rainy Creek and the tailings pond, with detected levels ranging from 219 to 9,438 total LA f/mL (Table 3-3). Asbestos was also detected in sediment from the upper tailings pond (Table 3-4).

Phase I Sampling Results

[will insert when data becomes available.....]
Figure 3-5
Table 3-5

3.3 Tree Bark

Prior to Phase 1

Ward et al. (2006) collected tree bark samples from three heavily forested locations near the Libby vermiculite mine and former processing areas. Samples were collected in November 2004 in support of a firewood harvesting and commercial logging exposure study. Sampling locations near the mine site were selected to represent expected high (Location 1), medium (Location 2), and low (Location 3) asbestos levels. Figure 3-6 provides the sampling locations for tree bark. Samples were collected from coniferous trees (lodgepole pine, ponderosa pine, larch, Douglas fir) approximately 4 feet from the base of the tree. Samples were analyzed for asbestos by Transmission Electron Microscopy (TEM) using counting methods as specified in the Asbestos Hazardous Emergency Response Act of 1986 (AHERA 1986). For the purposes of reporting analytical results, it was assumed that the surface area of each sample was 2 cm^2. Table 3-6 presents the asbestos levels for tree bark collected near the Libby vermiculite mine. As seen, asbestos loading on tree bark ranged from 14,000,000 to 260,000,000 f/cm^2, with levels tending to be lowest at Location 3 and highest at Location 1.

Phase I Sampling Results

[will insert when data becomes available.....]
Figure 3-7
Table 3-7

3.4 Air

Prior to Phase 1

EPA has collected numerous personal and stationary air monitoring samples for analysis of asbestos as part of clean-up activities within OU3. Personal air monitoring data is collected for all clean-up workers to ensure that exposures are not above Occupational Safety and Health Administration (OSHA) levels of concern and to determine the appropriate level of personal protective equipment (PPE) needed during clean-up activities. Most of the stationary air monitoring samples within OU3 were collected along roadways within the mine area, Rainy Creek road, and Highway 37 N. Table 3-8 summarizes the TEM results for stationary air monitoring samples collected within OU3. As seen, between 30-50% of all stationary air samples collected prior to 2002 were detect for LA, with detected LA concentrations ranging up to 0.2 s/cc.

Phase I Sampling Results

[will insert when data becomes available…..]
Figure 3-8
Table 3-9

3.5 Biota

EPA's Environmental Monitoring and Assessment Program (EMAP) collected aquatic community data at a station on the Kootenai River about one mile downstream of the confluence with Rainy Creek. This location was sampled in August 2002. Forty-four species of aquatic invertebrates (Table 3-10) and eleven species of fish (Table 3-11) were collected from this location.

4.0 PRELIMINARY EFFECTS ASSESSMENT

In order to understand the potential effects of asbestos on ecological receptors, a literature search was completed to identify information on the effects of asbestos on ecological receptors. The literature search and results are detailed in Appendix A. The following paragraphs describe the extent of data identified ~~to data~~ for each general ecological receptor group.

[Text near completion]

Attachment A is a list of NOAELs & LOAELs from the literature. This does not provide an ~~overview of~~ Exposure profile, or ~~potential effects,~~ Effects profile. This is ~~only~~ a list of potential Benchmarks.

4.1 Fish
4.2 Aquatic Invertebrates and Plants
4.3 Terrestrial Plants
4.4 Mammals
4.5 Birds
4.6 Soil Invertebrates
4.7 Terrestrial Plants
4.8 Amphibians

5.0 SITE CONCEPTUAL MODEL

One of the first steps in planning an ecological risk assessment is the development of a Conceptual Site Model (CSM). The CSM is a schematic summary of what is known about the nature of source materials at a site, the pathways by which contaminants may migrate through the environment, and the scenarios by which receptors (both human and ecological) may be exposed to site-related contaminants. When information is sufficient, the CSM may also indicate which of the exposure scenarios for each receptor are likely to be the most significant, and which (if any) are likely to be sufficiently minor that detailed evaluation is not needed. The CSM is therefore helpful in identifying environmental media that may require sampling in order to evaluate exposure and risk from site-related releases.

5.1 Contaminant Fate and Transport

<u>Sources of Libby Amphibole (LA) Asbestos</u>

The preliminary contaminant of concern at OU3 is a form of asbestos referred to as Libby amphibole (LA). When the mine, mill and processing facilities were operating, activities at these released LA fibers to the air and soil. The mining activities also generated solid wastes (e.g., tailings and waste rock) that are also sources of LA. Figure 2-5 shows the current mine features and location of historical operations.

<u>Migration Pathways in the Environment</u>

From the sources, LA may be released and transported via airborne emissions, surface water transport or food chain transport.

> *Airborne Transport.* Because LA fibers are small, they may become suspended in air from release mechanisms such as wind or mechanical disturbances. Once airborne, LA fibers will tend to move with the air. The time that the fibers remain in air (and hence the distance they may move before returning to earth) depends on the size of the particle and air flow turbulence, and may range from only a few minutes to a number of hours. — days no?

What about degradation & dissolution? Adsorption?

What is LA? how is it different from chrysotile etc...

Surface Water Transport. Although asbestos is not soluble in water, suspended particles may be carried in surface water runoff (e.g., from rain or snowmelt) from the mine or other areas where soil is contaminated by LA, and depositied in soils or sediments at downstream locations. Fibers may then be released to the air from contaminated soils or dried sediments by either wind or mechanical disturbances.

Food Chain Transport. Asbestos may be taken up into the tissues of aquatic organisms (fish and/or benthic invertebrates) from water and/or sediment and into terrestrial prey items (plants, soil invertebrates, birds, and mammals) from soil.

Provide a discussion of sensitive habitat / critical habitat, ES species (State & Federal) - species of concern etc.

5.2 Potentially Exposed Ecological Receptors

Seven general groups of ecological receptors are identified as possibly exposed to asbestos including fish, benthic invertebrates, plants, soil invertebrates, birds, mammals and amphibians. The Montana Natural Heritage Program is a source for information on the status and distribution of native animals and plants, emphasizing species of concern and high quality habitats (such as wetlands). As an initial assessment of which species within the general receptor groups that are expected to occur at the Libby OU3 site, a search was completed of the Montana Natural Heritage Program Animal Tracker http://nhp.nris.mt.gov/Tracker/. Attachment B provides a list of the species identified in Lincoln County, Montana. Some species were added or removed from the Lincoln County list based on the type of habitat at the Libby OU3 site. The Montana Natural Heritage Program and Montana Fish, Wildlife and Parks maintains an Animal Field Guide on the internet (http://fieldguide.mt.gov/) that provides information on identification, habitat, ecology, reproduction, range, and distribution of Montana's animals. The Plant Field Guide offers information on plant species of concern, including references and photographs. For each of the species identified as occurring within Lincoln County, information was added to Attachment B concerning general habitat information, habitat type for foraging and nesting, feeding guide, typical food, migration and hibernation, longevity and size, oldest recorded sighting in Montana and latest (year) and the number identified. Also included in the table for each species are global and state status. Montana employs a standardized ranking system to denote global (G - range-wide) and state status (S) (NatureServe 2003). Species are assigned numeric ranks ranging from 1 (critically imperiled) to 5 (demonstrably secure), reflecting the relative degree to which they are "at-risk". A number of factors are considered in assigning ranks - the number, size and distribution of known "occurrences" or populations, population trends (if known), habitat sensitivity, and threat.

5.3 Complete Exposure Pathways for Ecological Receptors

Figure 5-1 presents an initial CSM for exposure of each general ecological receptor group (fish, benthic invertebrates, plants, soil invertebrates, birds, mammals and amphibians) to asbestos that

This doesn't match fig 5-1 differences are important

summarizes EPA's current understanding of the environmental media that are likely to be contaminated by past and ongoing releases of asbestos from the mine and pathways by which ecological receptors might be exposed, now or in the future. The CSM identifies the exposure pathways that may be occurring, now or in the future. However, not all pathways are equally likely to be important. In each CSM, pathways are divided into four main categories:

- A solid black circle (●) represents pathways that are believed to be complete, and which may provide an important contribution to the total risk to a receptor.

- An open circle (O) represents an exposure pathway that is believed to be complete, but which is unlikely to be a major contributor to the total risk to a receptor, at least in comparison to one or more other pathways that are evaluated.

→ Can we update any of these ?'s to ● or O based on incoming data

- A question mark (?) represents an exposure pathway that is believed to be complete, but data available are not adequate to decide if the pathway is or is not a major contributor to the total risk to the receptor.

- An open box represents an exposure pathway that is believed to be incomplete (now and in the future). Thus, this pathway is not assessed.

A range of different ecological receptors may be exposed. Potential exposures for each receptor group are discussed in the following paragraphs.

[before the discussion of each receptor group need to insert a discussion of role and importance to other receptors groups, community, etc..]

Fish

This receptor group may be exposed via ingestion/direct contact with asbestos in surface water and sediment. Fish may also be exposed to asbestos via ingestion of food items that have accumulated asbestos in their tissues.

Benthic Invertebrates

This receptor group may be exposed via ingestion and direct contact with asbestos in surface water and sediment. Benthic invertebrates may also be exposed to asbestos via ingestion of food items that have accumulated asbestos in their tissues.

Terrestrial Plants

This receptor group may be exposed via direct contact with asbestos in soil or as the result of deposition onto leaf surfaces.

Aquatic Plants

This receptor group may be exposed via direct contact with asbestos in surface water and/or sediments.

Mammals and Birds

These receptor groups may be exposed via inhalation of airborne emissions from soils disturbance, solid waste disturbance, on-site material disturbance, tree bark and foliar disturbance and sediment disturbance. These receptor groups may also be exposed to asbestos in soils, surface water, sediment and food via ingestion and direct contact. Mammals and birds may also be exposed to LA in soil as a result of the uptake of LA into the tissues of terrestrial prey items (plants, soil invertebrates and other mammals and birds).

Direct contact exposures are expected to occur but are unlikely to be a major contributor to the total risk compared to the ingestion and inhalation pathways. Currently toxicity data on inhalation and ingestion asbestos exposures for avian species are not available. This lack of information prevents an evaluation of the relative contribution of exposure pathways to the total risk.

This is essentially the same for all receptor groups. Why are you singling out Avian?

Amphibians

This receptor group may be exposed via inhalation of airborne emissions from soils disturbance, tree bark and foliar surface disturbance and sediment disturbance. This receptor group may also be exposed to asbestos in soils, surface water, sediment and food via ingestion and direct contact. Amphibians may also be exposed to asbestos as a result of the uptake of asbestos into the tissues of terrestrial and aquatic prey items (plants, soil invertebrates, birds, mammals, fish and benthic invertebrates). Currently toxicity data on inhalation, ingestion and direct contact asbestos exposures for amphibian species are not available. This lack of information prevents an evaluation of the relative contribution of exposure pathways to the total risk.

and exposure data

5.4 Selection of Representative Wildlife Species

It is not feasible to evaluate exposures and risks for each avian and mammalian species - potentially present at the site. For this reason, specific wildlife species are identified as surrogates (representative species) for the purpose of estimating exposure and risk. The surrogate species are wildlife species present at the site that are representative of other species that occupy a similar niche (in terms of habitat, diet and foraging area). These representative species will be used to quantify asbestos exposures (doses). The species were selected based on the following considerations:

spawn fidelity migration nesting

- Small body size – Smaller body size was preferentially selected as these species are expected to receive higher doses.
- Small home range - A small home range increases the likelihood that the species will forage within the area of contamination.
- Feeding guild – Species were selected to represent both those that forage and live primarily in trees (arboreal) and on the ground. An invertivore that forages on the ground was selected for both mammals and birds. For mammalian species, as most small rodent species are omnivorous, an omnivore that forages (and either nests on the ground or burrows) was selected. For avian species, as most ground foraging birds are herbivorous, an herbivore was selected. For both mammals and birds a carnivore was selected. For mammals, a species that feeds on aquatic organisms was selected. For avian species two species that feed on aquatic organisms were selected: one primarily on fish and the other on invertebrates.
- Occurrence in Lincoln, County, Montana – Species were preferentially considered that were frequently reported to occur in Lincoln County according to the Montana Natural Heritage Program (Attachment B).
- Availability of Parameter Data – Species were preferentially selected for which exposure parameter data (ingestion rates, body weights, etc.) were available.

The species identified as surrogate species for Libby OU3 upon the review of information in Attachment B include:

Representative Wildlife Species			
Group		Species	Represents
Mammalian	Invertivore-Ground	Masked shrew (*Sorex cinereus*)	Mammalian insectivorous species that feed primarily on soil invertebrates, forage on the ground and inhabit underground burrows
Mammalian	Omnivore-Arboreal	Northern Flying Squirrel (*Glaucomys sabrinus*)	Mammalian omnivorous species that feed and nest primarily in trees.
Mammalian	Omnivore-Ground	Deer Mouse (*Peromyscus maniculatus*)	Mammalian omnivorous and herbivorous species that feed on plants and some insects, forage on the ground and inhabit underground burrows or ground nests
Mammalian	Carnivore	Marten (*Martes americana*)	Mammalian carnivorous species that feed primarily on small mammals
Mammalian	Piscivore/Aquatic Invertivore	Mink (*Mustela vison*).	Semi-aquatic mammalian species that feed primarily on fish and some invertebrates.
Avian	Invertivore-Ground	American robin (*Turdus migratorius*)	Avian insectivorous passerine species that feed primarily on soil invertebrates.
Avian	Invertivore- Arboreal	Brown Creeper (*Certhia Americana*)	Avian species that forage and nest on live trees
Avian	~~Herbivore - Ground~~	~~Ruffed Grouse (*Bonasa*~~	~~Avian species that feed primarily on plant material and~~

Red Squirrel/ Chipmunk

What about large mammals Deer/Elk

Representative Wildlife Species			
Group		Species	Represents
		umbellus)	forage on the ground.
	Carnivore	American Kestrel (*Falco sparverius*)	Avian species that feed on other birds and small mammals.
	Aquatic Invertivore	Spotted Sandpiper (*Actitis macularius*)	Avian species that forage along streams and ponds probing into sediments and riparian soils.
	Piscivore	Belted kingfisher (*Ceryle alcyon*)	Represents piscivorous avian species that feed primarily on fish and some invertebrates.

6.0 MANAGEMENT GOALS

Management goals are descriptions of the basic objectives which the risk manager wishes to achieve. The overall management goal identified for ecological health at the Libby OU3 site for asbestos is:

> Ensure adequate protection of ecological receptors within the impacted area of the Libby OU3 Site from the adverse effects of exposures to asbestos. "Adequate protection" is generally defined as the reduction of risks to levels that will result in the recovery and maintenance of healthy local populations and communities of biota (USEPA, 1999).

The "impacted area" of the Libby OU3 site will be identified based on the results of the Phase I sampling. The boundary of the "impacted area" will be based on the aerial extent of asbestos contamination that can be established based on the results of analyses of asbestos in tree bark, soils and air. The original working boundary line of the OU3 may or may not represent this impact boundary.

A "population" can be defined in multiple ways. A common definition of the biological population by ecologists is: "A group of plants, animals and other organisms, all of the same species that live together and reproduce. Individual organisms must be sufficiently close geographically to reproduce. Sub-populations are parts of a population among which gene flow is restricted, but within which all individuals have some chance of mating any other individual" (Menzie et al., 2007). "Population" can also be defined differently in the context of a management goal. To prevent miscommunication in risk assessment and risk management, use of the term "assessment population" is recommended (USEPA, 2003). In problem formulation it is necessary to explicitly state the assessment population(s). The assessment population may be the same as the biological population as defined by ecologists or may be: 1) a component of the biological population (e.g., exposed population); or, 2) a component of relevant metapopulation (e.g., a subpopulation). For the Libby OU3 Site, the assessment populations are defined as the groups of organisms exposed at the site (reside within the "impacted area"). That is, the focus is on ensuring sustainability of local populations, rather than on protection of every individual in a population. In order to provide greater specificity regarding the general managed goal and to identify specific measurable ecological values to be protected, the following list of sub-goals was derived:

I think this is too strong. Populations will be evaluated with inference in some cases - extrapolation

This was divided into disturbed vs undisturbed due to change in D. Humes

- Ensure adequate protection of the aquatic communities in Rainy Creek, Fleetwood Creek, the Tailings Impoundment, Lower Pond and Carney Creek from the adverse effects of exposures to asbestos.

- Ensure adequate protection of terrestrial plant and soil invertebrate communities within the ~~impacted~~ area, from the adverse ~~effects of acute and chronic exposures to~~ asbestos.

- Ensure that the individuals comprising the terrestrial mammal assessment population(s) and bird assessment population(s) are able to carry out biological functions that influence their ability to maintain themselves within the area of evaluation and enable them to fully contribute to the larger biological population. These biological functions include ~~survival, growth~~ and reproduction.

- Ensure that the individuals comprising the ~~amphibian assessment~~ population(s) are able to carry out biological functions that influence their ability to maintain themselves within the area of evaluation and enable them to fully contribute to the larger biological population. These biological functions include survival, growth and reproduction.

7.0 ASSESSMENT AND MEASUREMENT ENDPOINTS

Assessment endpoints are explicit statements of the characteristics of the ecological system that are to be protected. Assessment endpoints are either measured directly or are evaluated through indirect measures. Measurement endpoints were initially defined by EPA guidance to represent quantifiable ecological characteristics that could be measured, interpreted, and related to the valued ecological components chosen as the assessment endpoints (USEPA 1992, 1997a). The term measurement endpoint was later replaced with the term *measures of effect* and was supplemented by two other categories of measures (USEPA, 1998). This problem formulation still uses the term measurement endpoint to describe both measures of exposure and effect. Assessment endpoints are identified, measurement endpoints and test hypothesis. Lines of evidence and measurement endpoints (measurements of effect and exposure) will be further delineated in Step 4 (Study Design and DQO Process) that will part of the Phase II Sampling and Analyses Plan for Libby OU3.

7.1 Methods

These lines of evidence can be divided into four basic categories of approach, as follows:

- Hazard Quotients (HQs)
- Site-specific toxicity tests with collected environmental media
- *In-situ* measurements of exposure and effects
- Observations of population and community demographics

Each of these basic approaches is described in the following subsections.

Hazard Quotients (HQs)

A Hazard Quotient (HQ) is the ratio of the estimated exposure of a receptor to a "benchmark" that is believed to be without significant risk of unacceptable adverse effect:

where do we get a benchmark Do we have any

HQ = Exposure / Benchmark

Exposure may be expressed in a variety of ways, including:

- Concentration of asbestos in an environmental medium (water, sediment, and soil)
- Concentration of asbestos in the tissues of an exposed receptor
- Amount of asbestos ingested by a receptor

In all cases, the exposure and benchmark must be expressed in like units. For example, exposure in surface water (fibers/L) must be compared to a benchmark in fibers/L and an exposure to asbestos in muscle tissue (fibers/kg) must be compared to a benchmark for muscle tissue (fibers/kg). If the value of an HQ is less than or equal to 1E+00, risk of unacceptable adverse effects in the exposed individual is judged to be acceptable. If the HQ exceeds 1E+00, the risk of adverse effect in the exposed individual is of potential concern.

However, not all HQ values are equal. Interpretation of the consequences associated with either the magnitude of HQ values and/or the number of HQ values that exceed one depends on the species being evaluated and on the toxicological endpoint underlying the toxicity benchmark. In most cases, HQ values are not based on site-specific toxicity data, and do not account for site-specific factors that may either increase or decrease the toxicity of the metals compared to what is observed in the laboratory. Consequently, most HQ values should be interpreted as estimates rather than highly precise predictions and should be viewed as part of the weight-of-evidence along with the results of site-specific toxicity testing and direct observations on the structure and function of either the aquatic or terrestrial community.

Site-Specific Toxicity Tests (SSTT)

Site-specific toxicity tests measure the response of receptors that are exposed to site media. This may be done either in the field or in the laboratory using media collected on the site. The chief advantage of this approach is that site-specific conditions which can influence toxicity are usually accounted for. A potential disadvantage is that, if toxic effects are observed to occur when test organisms are exposed to site media, it is usually not possible to specify which contaminant or combination of contaminants is responsible for the effect. Rather, the results of the toxicity testing reflect the combined effect of the mixture of contaminants present in the site medium. In addition, it is often difficult to test the full range of environmental conditions which may occur at the site across time and space, either in the field or in the laboratory, so these studies are not always adequate to identify the boundary between exposures that are acceptable and those that are not.

Standard tox tests / spiking. no discussion of how little we know about LA

Population and Community Demographic Observations (PCDO)

Another approach for evaluating impacts of environmental contamination on ecological receptors is to make direct observations on the receptors in the field, seeking to determine whether any receptor population has unusual numbers of individuals (either lower or higher than expected), or whether the diversity (number of different species) of a particular category of receptors (e.g., plants, benthic organisms, birds) is different than expected. The chief advantage of this approach is that direct observation of community status does not require making the numerous assumptions and estimates needed in the HQ approach. However, there are also a number of important limitations to this approach. The most important of these is that both the abundance and diversity depend on many site-specific factors (habitat suitability, availability of food, predator pressure, natural population cycles, meteorological conditions, etc.), and it is often difficult to know what the expected (non-impacted) abundance and diversity should be in a particular area. This problem is generally approached by seeking an appropriate "reference area" (either the site itself before the impact occurred, or some similar site that has not been impacted), and comparing the observed abundance and diversity in the reference area to that for the site. However, it is sometimes quite difficult to locate reference areas that are truly a good match for all of the important habitat variables at the site, so comparisons based on this approach do not always establish firm cause-and-effect conclusions regarding the impact of environmental contamination on a receptor population.

In-Situ Measures of Exposure and Effects (IMEE)

An additional approach for evaluating impacts of environmental contamination on ecological receptors is to make direct observations on receptors in the field, seeking to determine whether individuals have higher exposure (tissue) levels, observed lesions and/or deformities in individuals that are higher than expected. This method has the advantage of integrating most (if not all) factors that influence the bioavailability of contaminants in the field and does not require making the numerous assumptions and estimates needed in the HQ approach. The limitations of this method may be in the interpretation of the consequences of the measured exposure or effect (if suitable toxicity information are not available) and if an appropriate reference population for comparison is available.

Weight of Evidence Evaluation

As noted above, each of the measurement endpoints has advantages but also has limitations. For this reason, conclusions based on only one method of evaluation may be misleading. Therefore, the best approach for deriving reliable conclusions is to combine the findings across all of the methods for which data are available, taking the relative strengths and weaknesses of each method into account. If the methods all yield similar conclusions, confidence in the conclusion is greatly increased. If different methods yield different conclusions, then a careful review must be performed to identify the basis of the discrepancy, and to decide which approach provides the most reliable information.

7.2 Risk Questions

Guidance for ecological risk assessments at Superfund Sites (USEPA, 1997) recommends forming risk assessment questions to frame the initial scope of the baseline risk assessment (USEPA, 1997). These are basically questions about the relationships among assessment endpoints and their predicted responses when exposed to contaminants. The risk questions are based on the assessment endpoints and provide a basis for developing the study design in the next step of the process (Figure 1-1) which will be the study plan and design in the Phase II SAP and QAPP for the Libby OU3 site. The initial risk questions formed are listed in Table 7-1 along with the selected assessment endpoints.

7.3 Selected Endpoints

Table 7-1 presents the assessment endpoints, measurement endpoints, and test hypothesis identified for use to interpret potential ecological risks for the Libby OU3 mine site. The table also lists the measurement endpoints that were considered but were not selected for use. In most cases this was due to a lack of necessary information. These endpoints will form the basis of the design of sampling in the Phase II SAP and QAPP for the Libby OU3 Site.

[Insert further text discussion on why some endpoints were not selected. Should we develop testable hypotheses here or in the SAP/QAPP?. Should a discussion be inserted on pros and cons?]

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TABLES

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